PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of	Docket No: Q78557
Setsuo MISHIMA, et al.	
Appln. No.: 10/715,568	Group Art Unit: 1742
Confirmation No.: 5060	Examiner: Kathleen A. McNelis
Filed: November 19, 2003	

For: MARAGING STEEL AND METHOD OF PRODUCING THE SAME

SUBMISSION OF SCHEMATIC MATERIAL

Fax to Examiner: (571-273-3554)
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Pursuant to a telephone interview with the Examiner on August 21, 2007, where the Examiner agreed to a telephone interview on August 28, 2007, Applicants submit herewith two (2) pages of hypothetical schematics for consideration prior to the telephone interview on August 28, 2007.

The following explanation is offered on the schematic of the hypothetical Applicants wish to discuss. The bolded material reflects the titles in the left column. The discussion offered is in terms of the schematic where the Inventive steel (middle column) and the Conventional steel (Mg free) (right column) are shown.

TiN after primary melting (at electrode)

As is seen to the right of this heading in the first block of the hypothetical schematic, a consumable electrode made of the inventive steel contains a predetermined additive Mg for vacuum arc remelting (VAR). This is obtained from a molten steel produced by vacuum induction melting (VIM). There can be seen a generally hexagonal TiN inclusion and a nucleus

of MgO in the TiN inclusion. It is important for the consumable electrode to contain remaining Mg.

In the right block, the Conventional steel (Mg free), of course, contains no Mg. The TiN has been crystallized and grown during solidification of casting having the form of a consumable electrode.

TiN behavior in electrode (A) under VAR operation

As can be seen, in the Inventive Steel, TiN dissolve into an electrode. A similar effect is seen in Conventional steel (Mg free).

TiN behavior in liquid drop and pool of liquid metal (B) under VAR operation

This is secondary melting (i.e., remelting).

For the Inventive Steel middle column, the consumable electrode is subjected to vacuum arc remelting (VAR) during which MgO generally disappears and the TiN inclusions are refined. The principle here is not exactly clear, but it is thought that Mg which has formed the nucleus MgO vaporizes by heating during VAR under high vacuum, whereby MgO decomposes to promote decomposition of TiN inclusions, making it possible to prevent the phenomenon that remaining TiN grows and coarsens during solidification. The Behavior of TiN and Behavior of the elements in molten steel are illustrated in schematic form down the middle column, with the effects being explained at the bottom of the block of the middle column for Inventive Steel.

On the other hand, in Conventional steel (Mg free), while Behavior of TiN and Behavior of the element in molten steel are illustrated, the effects which result are explained at the bottom of the right column.

The key aspect of the present invention is to control amount of Mg in VIM and VAR processing, thereby also controlling (decreasing) oxide type inclusions. Specifically, since Mg is controlled to remain in the steel during VIM, it is possible to deprive Al_2O_3 and/or Al-Mg-O type (i.e., MgO- Al_2O_3 type) inclusions of oxygen, whereby it is possible to decrease oxide type inclusions.

TiN Behavior in Mushy Zone (C) under VAR Operation

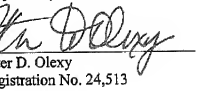
The last series of blocks illustrate the behavior of TiN in the Mushy zone.

The effects of the Inventive Steel versus the effects in the Conventional steel (Mg free) are explained at the very bottom of the last series of block. of the hypothetical schematics.

It is hoped that the above will be of some assistance to the Examiner.

In the case for non-metallic inclusions, especially TiN-type non-metallic inclusions which have grown in a steel, material fracture is initiated from such non-metallic inclusions. Thus, in the case where the Ti-containing maraging steel is used in motor vehicle components, a substantial problem to solve is restraining the growth of non-metallic inclusions in a Ti-containing maraging steel.

Respectfully submitted,



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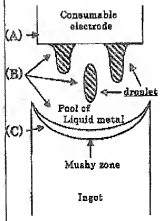
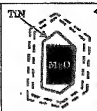
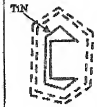
Date: August 24, 2007

TiN behavior in liquid drop and pool of liquid metal(B) under VAR operation.





<Behavior of TiN>
$TiN \rightarrow \underline{Ti}+\underline{N}$
Ti and N dissolves into a liquid metal.
<Behavior of the elements in molten steel>
$\underline{Mg} \rightarrow Mg(g)$
$2\underline{N} \rightarrow N_2(g)$



<Behavior of TiN>
$TiN \rightarrow \underline{Ti}+\underline{N}$
$MgO \rightarrow \underline{Mg}+\underline{O}$
If the dissolution of TiN reaches to MgO, MgO will disappear from TiN by decomposition of MgO.
Ti, N, Mg, and O are dissolves in molten steel.

<Behavior of the elements in molten steel>
$\underline{Mg} \rightarrow Mg(g)$
$2\underline{N} \rightarrow N_2(g)$
$2\underline{O} \rightarrow O_2(g)$
$\underline{O}+\underline{C} \rightarrow CO(g)$

TiN dissolves.
Since MgO was included, as compared with Mg free material, the volume of TiN is small.
Furthermore, since MgO decomposed or drop out, the surface area of TiN increases and TiN easily dissolves.

<Behavior of TiN>
$TiN \rightarrow \underline{Ti}+\underline{N}$

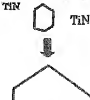
<Behavior of the element in molten steel>
$2\underline{N} \rightarrow N_2(g)$

By the dissolution, TiN becomes small. However, TiN does not completely dissolve.

TiN behavior in Mushy zone (C) under VAR operation.

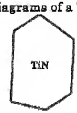
TiN newly forming in Mushy zone.

TiN forming in Mushy zone grows.



TiN begins growth.

TiN grows further. And it becomes larger than the TiN size at the time of the end of VIM.

	Inventive steel	Conventional steel (Mg free)
TiN after primary melting (at electrode)	The cross-sectional pattern diagrams of a TiN 	
TiN behavior in electrode(A) under VAR operation.	 TiN→Ti+N Ti and N dissolves into an electrode.	 TiN→Ti+N Ti and N dissolves into an electrode.